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How Insects Affect Health in Rural Districts.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 7, 1908.

Sir: I have the honor to transmit herewith a revision of Farmers' Bulletin No. 155, entitled "How Insects Affect Health in Rural Districts," and recommend its republication in the present form. The article was originally prepared by me for the Yearbook for 1901, in which it appears under a different title, but in view of the very general interest in the subject it has seemed desirable to republish the matter for wide distribution to farmers, to whom the information contained in the article is especially pertinent.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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HOW INSECTS AFFECT HEALTH IN RURAL DISTRICTS.

INTRODUCTION.

In very many parts of the country the farming population has to contend with at least two diseases which are preventable. These are malaria and typhoid fever. Both of these diseases are transferred or may be transferred by insects—malaria by certain mosquitoes and typhoid fever by the common house fly, or certain other flies.

CITY AND COUNTRY CONDITIONS COMPARED.

While it is true that both malaria and typhoid prevail in large cities, it is none the less true that they may with a certain degree of accuracy be termed country diseases, that is to say, rather specifically, diseases of the farm and the small village. Malaria, in fact, has been called by medical men a country disease. Swampy regions do not occur in cities, or, at all events, only in the suburbs, whereas they occur commonly in the country. Open streams with side pools of still water are found only in the country, and it is in such small, still pools, and in more or less permanent but small accumulations of water, that the malarial mosquito breeds. This mosquito, therefore, does not accommodate itself well to city conditions, but it is found almost everywhere in the country, except possibly in very dry localities and at certain high elevations. Even in dry regions it sometimes abounds, especially where there is a definite rainy season, or where the land is irrigated. Irrigating ditches are prolific breeding places for mosquitoes, including the malarial kind. Malaria in cities, as a rule, is found only with persons who have contracted it in the country or in the suburbs, although with some cities having marshy places on their borders a malarial belt may exist, the extent of which depends upon the direction and force of the prevailing summer breezes, especially the night breezes. For example, such a condition as this accounts for the prevalence of malaria in certain portions of the city of Washington before the reclamation of the Potomac Flats, which lie to the south of the city, the prevailing night breezes of the summer being southern.

SOURCES OF TYPHOID FEVER.

Cities well supplied with water from a reservoir, especially a filter reservoir, which possess a modern sewage system, and in which water-closets are universal, derive typhoid fever only from the following sources: Country milk contaminated through vessels washed in water infected with typhoid germs, the return of people in the autumn from the less sanitary country, and lack of care in the disposal of the discharges of persons who have contracted typhoid from either of the first two sources.

In the country, however, conditions are different. Each country house or each house in a small village has its own water supply, usually in the shape of a well; there are few water-closets, and excreta are deposited in the open or in box privies; drainage from these box privies or from the open deposits containing virulent typhoid germs may enter the streams, or the germs may be carried by underground drainage directly into the wells from which drinking water is gained; or, exposed as these box privies or open deposits usually are, certain flies may alight upon the excrement and carry the germs directly to the food supply of the houses; or certain flies may breed in this excrement and fly, fairly reeking with disease-bearing filth, to the kitchens and tables of nearby houses. When we consider that active typhoid germs may be given out for some time by persons who have not developed typhoid fever sufficiently so that it may be recognized, and that they may also be given out for some time after patients have been apparently cured of the disease, it is perfectly obvious that in the country the lack of care with which excreta are deposited readily accounts for outbreaks of typhoid fever from any of the causes mentioned.

METHODS OF PROTECTION FROM TYPHOID AND MALARIA.

Of course it will be said that the entire water supply of a city may become contaminated at or immediately above its reservoir supply. This contamination is from country sources and might be obviated either in a general manner by the establishment of a reservoir filtering plant, or in a special manner by individual householders by the constant and thorough use of house filters. In cities possessing a common water supply and modern sanitary plumbing there is no excuse for the presence of typhoid in the household. Even the city water must be filtered, which can be done by the use of any one of the cheap filters now on the market; the milk which is drunk by children must be sterilized, and the excreta of persons returning to the city, after contracting typhoid fever in the country, must be disinfected with the utmost care. These three measures, systematically followed, will result in the abolition of typhoid fever within the city boundaries.

So much for cities. In the country the matter is somewhat more difficult, and immunity from malaria and typhoid depends largely upon the individual householder. Such immunity may be obtained, but only as a result of intelligent care.

Let us briefly consider what the farmer or the resident of a small village must do to bring about protection.

MALARIA.

The old idea that malaria is caused by breathing the miasma of swamps has been exploded. Malaria is contracted only through the bites of mosquitoes of the genus Anopheles. The cause of human malaria is the growth and development within the red blood cells of a very minute parasitic organism belonging to the lowest group of the animal kingdom—the group Protozoa, or one-celled animals, which includes those minute creatures known as Amœbas and others, and which live in the water or in damp sands or moss, or inside the bodies of other animals as parasites. This parasite reproduces in the body by subdividing, eventually bursting the red blood cells and entering the blood serum as a mass of spores. Broadly speaking, when the blood of a human being is sucked into the stomach of a mosquito of the genus Anopheles the malarial parasite undergoes a sexual development and gives birth to a large number of minute, spindle-shaped cells, known as blasts, which enter the salivary glands of the insect and are ejected with the poison into the system of the next person bitten by the mosquito. If this person happens to be nonmalarious the malaria has thus entered his system and malarial symptoms result.

So far as present knowledge goes this is the only way in which people become malarious. In order to avoid this result it is necessary to avoid the bites of malarial mosquitoes, and it therefore becomes important to know the differences between the malarial and the more harmless mosquitoes, and the conditions under which the malarial forms breed.

Malaria-bearing mosquitoes.—There are very many mosquitoes which have not yet been proven to carry any disease. In fact, the majority of mosquitoes are supposed to be harmless except for the irritation caused by their punctures. The commonest of all forms belong to the genus Culex. These include the mosquitoes most commonly breeding in rain-water barrels and chance transient pools. Fig. 1 shows the difference between a harmless mosquito of the genus Culex and the malarious mosquito of the genus Anopheles. It will be noticed that Culex has clear wings, while Anopheles has wings which are more or less spotted. It will be noticed further that while the palpi (which are the projections either side of the beak) are very short in Culex, they are long—nearly as long as the beak—in Anopheles. Further,

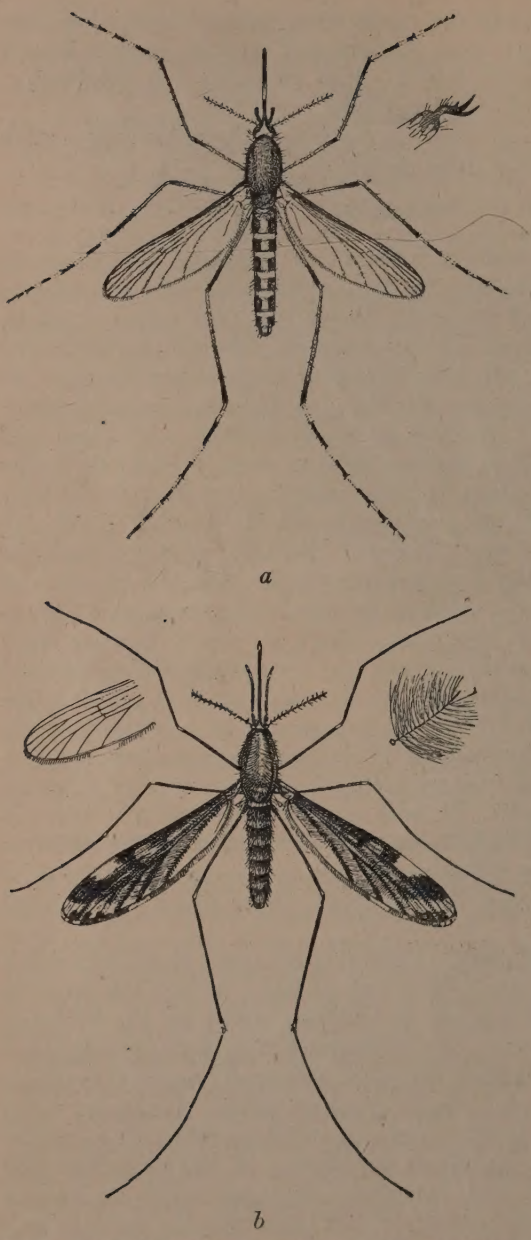

FIG. 1.—Adults of Culex and Anopheles: *a*, *Culex sollicitans*; *b*, *Anopheles punctipennis*. Enlarged (author's illustration).

it has been observed that when Culex is resting upon a wall it appears more or less humpbacked, that is to say, the head and the beak are not in the same plane with the body and wings, but project at an angle toward the surface of the wall, the body and wings being parallel with the wall. With Anopheles, however, the head and beak are in practically the same plane with the body, and the body itself is usually placed at an angle with the wall, and especially when resting upon a horizontal wall, such as the ceiling of a room, the body of Anopheles is at a very great angle with the surface. We have in this country three species of the malarial genus Anopheles, namely, *Anopheles maculipennis* (illustrated in fig. 2), *Anopheles punctipennis* (shown in fig. 1, *b*), and *Ano-*

pheles crucians (shown in fig. 3). The former two are found nearly all over the country, but the last is a more Southern species, although it has been found as far north as the south shore of Long Island.

As to the early stages, the eggs of Anopheles may be at once distinguished from the eggs of Culex by figs. 4 and 5, those of Culex being laid in the raft-shaped mass on end and those of Anopheles being laid singly upon the surface of the water, always lying upon their sides. The larvæ of Culex, commonly known as wigglers, are

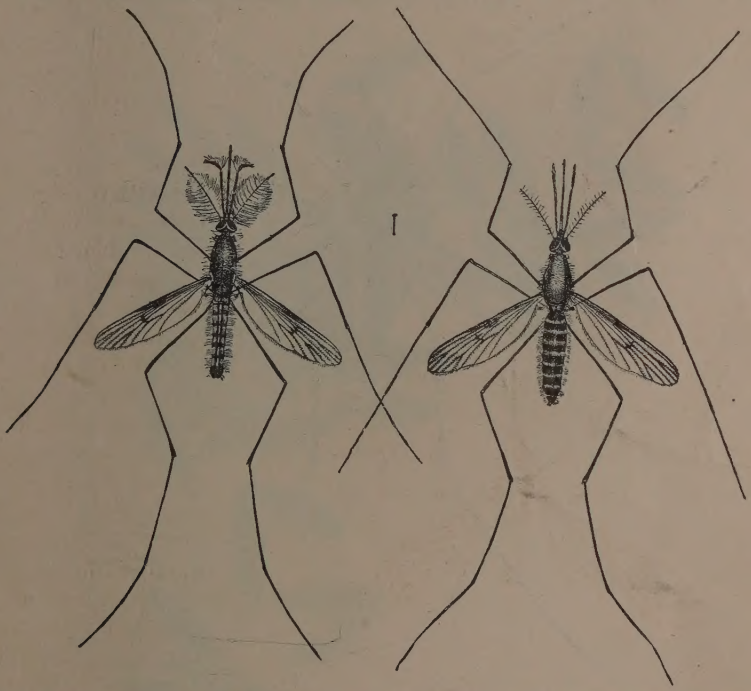

FIG. 2.—*Anopheles maculipennis:* Male at left; female at right. Enlarged (author's illustration).

familiar to almost everyone, and are the common wigglers found in horse troughs and rain-water barrels, which wriggle around in the water, returning at frequent intervals to the surface to breathe, and when at the surface hanging with simply the tip of the tail extruding, the rest of the body being held below the surface at a great angle. What we have called the "tail" is simply the breathing tube, which, with the common Culex wigglers, is long and more or less pointed. With the malarial mosquitoes, however, the wiggler, or larva, is of somewhat different shape, as shown in figs. 6 and 7, and when resting

at the surface, which it does most of the time, it lies with its body parallel with the surface, and not hanging down, as does the Culex wiggler. The pupæ of both forms are shown in fig. 8, and need not be described.

Breeding places of malaria-bearing mosquitoes.—The breeding places of the harmless mosquitoes are more numerous and more varied than the breeding places of the malarial mosquitoes. Anopheles, however, are found under many diverse conditions. They are found, as stated, in still side pools of small streams, in the swampy pools at the margins

FIG. 3.—*Anópheles crucians.* Enlarged (author's illustration).

of larger ponds, in stagnant water in ditches, in the beds of old canals, in the still water at the sides of springs, and occasionally, though rarely, in old horse troughs. They are perhaps more frequently found in such situations as described when a certain amount of green scum has accumulated, and it is upon the spores of the water plants constituting this green scum, as well as upon other very small objects floating on the surface of the water, that they principally feed.

Measures to be taken to prevent malaria.—To prevent malarial mosquitoes from breeding in a given vicinity, one should be prepared to

recognize their larvæ when they are seen, and to distinguish them from other mosquito larvæ; then a most thorough search for all possible breeding places should be made within a radius of a mile. This distance is mentioned, since it seems rather definitely proven that the Anopheles mosquitoes do not fly for great distances. After the breeding places are found they should be drained or filled in with earth, or they should be rendered uninhabitable to the Anopheles larvæ by covering the surface of the water with a thin film of kerosene oil, or by introducing certain fish which feed upon the larvæ, such as top minnows, sticklebacks, young sunfish, or goldfish.

FIG. 4.—Eggs of Anopheles. Enlarged (author's illustration).

Pending the result of such exterminating measures, all houses in malarious localities should be carefully screened to prevent the entrance of mosquitoes. After screening, thorough search should be made in the house for mosquitoes which have already gained entrance. Such as are found roosting upon the walls should be captured by placing an inverted vial over them, or they may be stupefied by burning a small amount of pyrethrum powder upon a tin dish cover. Persons wishing to avoid malaria should not sit out of doors exposed to

the bites of mosquitoes at night. Persons having malaria should be carefully screened at night to prevent them from being bitten by mosquitoes, which, becoming thus infected, would become potential carriers of the disease. Such patients, systematically treated with quinine, the dose being always given at the beginning of the chill, will soon be rid of the disease. The time of the dose is important, and the reasons for the time have been abundantly proven by the study of the life of the parasite in the blood cells.

All of this advice is given only after abundant demonstration of the efficacy of the methods. These measures have been followed with success in the most malarious localities in the world, and with this knowledge there is no good reason why an individual should contract

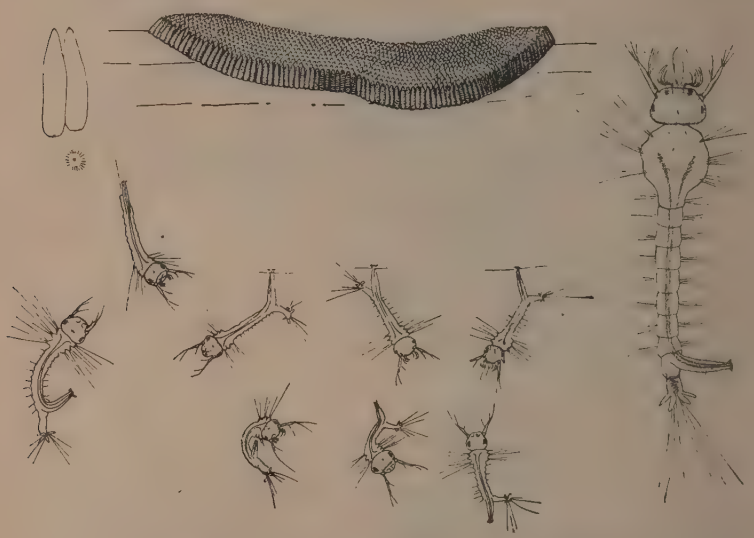

FIG. 5.—Eggs and larvæ of Culex. Enlarged (author's illustration).

malaria in his own home, no matter how much malaria exists around him.

Of course, however, there may be occasions where it is almost impossible to avoid contracting the disease. For example, the writer was once waiting for a night train one evening in a small Western town where there were irrigating ditches near the station. In these ditches malarial mosquitoes were breeding profusely, and the insects abounded in the station waiting room and on the platform. Nothing but a gauze covering would have kept them away, and several bites were inflicted on the hands and neck. Fortunately, none of the individuals could have bitten a malarial patient, as the disease was not transmitted.

It is not the writer's intention to go further into the causation of this disease than he has already done in his introductory remarks. He wishes, however, to point out as forcibly as possible the danger of its spread by insects and the methods of avoiding this danger.

House flies and breeding places.—The principal insect agent in this spread is the common house fly (fig. 9), and this insect is especially abundant in country houses in the vicinity of stables in which horses are kept. The reason for this is that the preferred food of the larvæ of house flies is horse manure. House flies breed in incredible numbers in a manure pile largely derived from horses. Twelve hundred house flies, and perhaps more, will issue from a pound of horse manure. Ten days completes a generation of house flies in the summer. The number of eggs laid by each female fly averages 120. Thus, under favorable conditions, the offspring of a single over-wintering house fly may in the course of a summer reach a figure almost beyond belief. With an uncared-for pile of horse manure in the vicinity of a house, therefore, flies are sure to swarm. Their number practically will be limited only by breeding opportunities. They are attracted to, and will lay their eggs in, human excrement. Under favorable conditions they will breed, to some extent, in this excrement. They swarm in kitchens and dining rooms where food supplies are exposed. They are found commonly in box privies, which sometimes are not distant from the kitchens and dining rooms. Therefore, with an abundance of flies, with a box privy near by, or with excremental deposits in the neighborhood, and with a perhaps unsuspected or not yet fully developed case of typhoid in the immediate neighborhood, there is no reason why, through the agency of contaminated flies alighting upon food supplies the disease should not be spread to healthy individuals. That it is so spread is not to be questioned. That under the unusual conditions of the army concentration camps

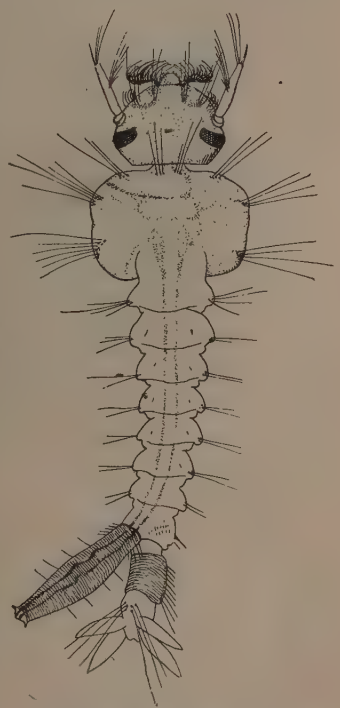

FIG. 6.—Full-grown larva of Culex. Enlarged (author's illustration).

in the summer of 1898 it was so spread to a shocking extent has been demonstrated by the army typhoid fever commission. And the remedy is plain. It consists of two courses of procedure: (1) Proper care of excreta; (2) the destruction of flies.

Measures to be taken to prevent typhoid fever.—On many farms where intelligent people live the old-fashioned box privy has been done away with, and there has been substituted for it some form of earth closet. Where a good earth closet is in operation, and the inhabitants of a farm appreciate the importance of using no other, and where in case of illness the excreta of patients are promptly disinfected, flies breeding in the neighborhood will have practically no opportunity to become contaminated with typhoid germs, except in the unlikely event (which future investigation may possibly show) that other animals than man are subject to this disease. The proper maintenance of an earth closet will add somewhat to the work of a farm, but this extra work will pay in the long run. While it is true that a box inclosure, if its contents are covered with lime every three or four days, will answer the purpose, a much better plan would be to use a large metal vessel, the surface of the contents being covered with earth after each operation, and which may be removed, emptied, and replaced daily. Care should, of course, be taken to empty the contents of the vessel in a pit constructed in some well-chosen spot, from which the drainage would not be dangerous.

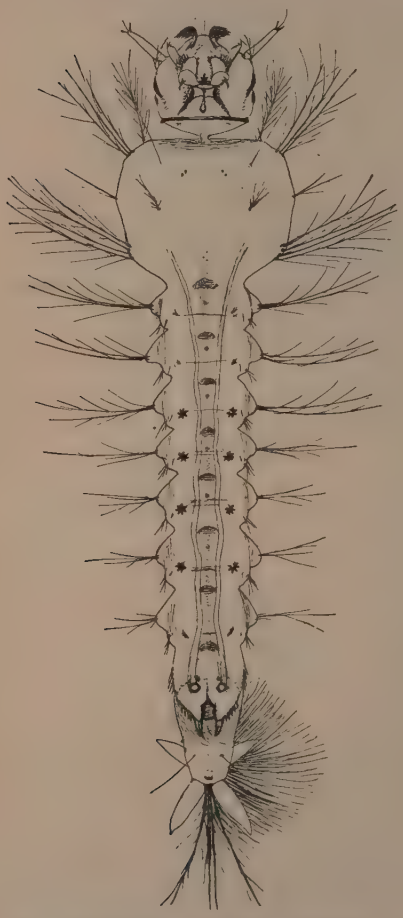

FIG. 7.—Full-grown larva of Anopheles. Greatly enlarged (author's illustration).

With regard to the abolition of flies, the best measures will again naturally involve some trouble and expense. In a thickly settled country it will become necessary for some such measure to be generally adopted in order to be perfectly effective, but in an isolated farm-

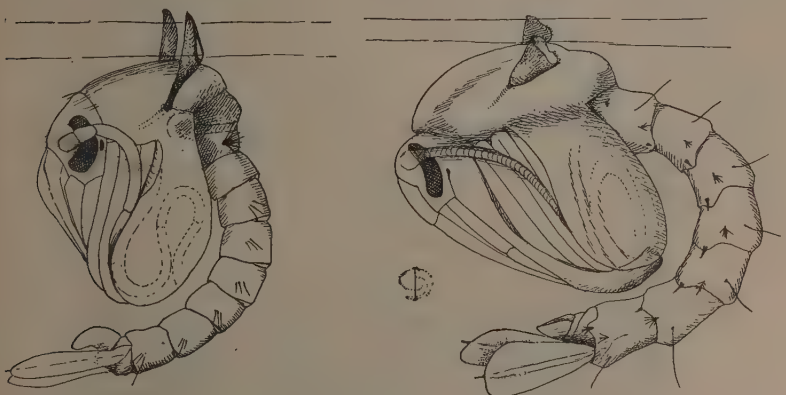

FIG. 8.—Pupa of Culex (at left) and Anopheles (at right). Greatly enlarged (author's illustration).

house the number of house flies may be greatly reduced by individual work. All horse manure accumulating in stables or barns should be collected, if not daily, at least once a week, and should be placed in either a pit or vault or in a screened inclosure like a closet at the side or end of the stable. This closet should have an outside door from

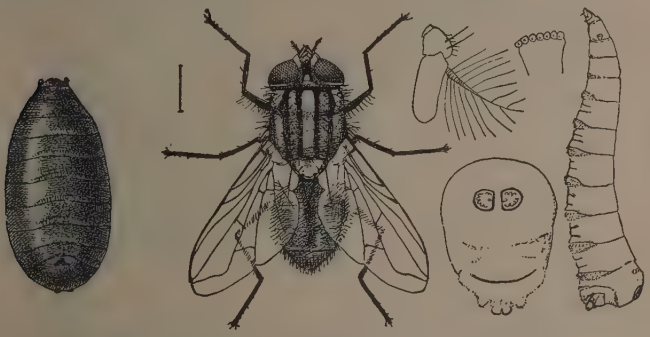

FIG. 9.—Common house fly (*Musca domestica*): Puparium at left; adult next; larva and enlarged parts at right. Enlarged (author's illustration).

which horse manure can be shoveled when it is needed for manuring purposes. Each day's or each week's accumulations, after they are shoveled into the closet or pit, should be sprinkled over the surface with chloride of lime, and a barrel of this substance can conveniently be kept in the closet. If this plan be adopted (and these recommen-

dations are the result of practical experience), house flies will have almost no chance to breed, and their numbers will be so greatly reduced that they will hardly be noticeable. Many experiments have been made in the treatment of manure piles in order to kill the maggots of the house fly, and the chloride-of-lime treatment has been found to be the cheapest and most efficacious.

It has been stated above that the closet for the reception of manure should be made tight to prevent the entrance or exit of flies. A window fitted with a wire screen is not desirable, since the corroding chloride fumes will ruin a wire screen in a few days.

Fruit flies.—While extended investigations have shown that the common house fly is the fly most to be feared in guarding against typhoid, on account of the fact that over 99 per cent of the flies found

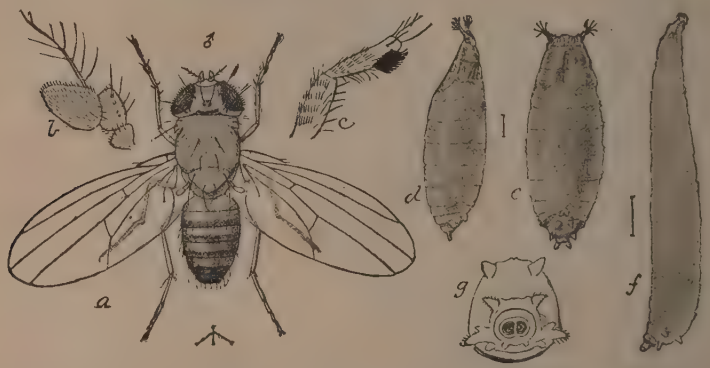

FIG. 10.—*Drosophila ampelophila*: *a*, Adult; *b*, antenna of same; *c*, base of tibia and first tarsal joint of same; *d*, puparium, side view; *e*, puparium from above; *f*, full-grown larva; *g*, anal spiracles of same. Enlarged (author's illustration).

in kitchens and dining rooms and attracted to food supplies are house flies, there are a few others which are attracted to and which may breed in human excrement that also have to be guarded against, and as these do not breed in horse manure the treatment just described will not be effective against them. The care of human excrement, however, will prevent the carriage of typhoid germs even by these species. The little fruit flies of the genus Drosophila (fig. 10), which breed in overripe or decaying fruit, are the principal species in this category. Therefore, fruit storehouses or fruit receptacles should be screened, and overripe fruit should not be allowed to remain in dining rooms or kitchens for any length of time.

OTHER DISEASES CARRIED BY INSECTS.

While in malaria and typhoid we have the two principal diseases common to the United States which may be conveyed by insects, the

agency of these little creatures in the transfer of disease germs is much more widespread in warm countries, and it is by no means confined to human beings. In Egypt and in the Fiji Islands there is a destructive eye disease of human beings the germs of which are carried by the common house fly. In our Southern States an eye disease known as pink-eye is carried by certain very minute flies of the genus Hippelates. In certain tropical countries a disease known as filariasis, which somewhat resembles certain forms of leprosy, is transferred among human beings by certain mosquitoes. There is good reason to suppose that the germs of the bubonic plague may be transferred from sick people to healthy people by the bites of fleas (fig. 11). The so-called Texas fever of cattle is unquestionably transferred by the common cattle tick (fig. 12), and this was the earliest of the clearly demonstrated cases of the transfer of disease by insects. In Africa a similar disease of cattle is transferred by the bite of the famous biting fly known as the tsetse fly (fig. 13) and the so-called

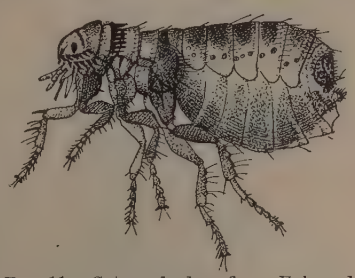

FIG. 11.—Cat and dog flea. Enlarged (original).

FIG. 12.—Cattle tick. Enlarged (redrawn from Salmon and Stiles).

"sleeping sickness" of human beings is conveyed by the same insect. The germs of the disease of cattle known as anthrax are carried by gadflies, or horse flies, and when these flies subsequently bite human beings malignant pustules may result (see fig. 14 for one of these gadflies); and other discoveries of this nature are constantly being

made. Even the common bedbug (fig. 15) is strongly suspected in this connection.

YELLOW FEVER.

One of the most important of these disease-transfer relations of insects which has been demonstrated is the carriage of yellow fever by certain mosquitoes. The cause of yellow fever has always been a mystery, and indeed it is a mystery to-day in a measure, since, although undoubtedly a disease of parasitic origin, the parasitic organism itself has not yet been discovered. During the summer and autumn of 1900 and spring and summer of 1901 the work of a commission of surgeons of the United States Army demonstrated in Cuba beyond the slightest possible doubt that yellow fever is not conveyed by infected clothing of yellow-fever patients or by contact

FIG. 13.—Tsetse fly. Enlarged (original).

FIG. 14.—Black gadfly. Enlarged (original).

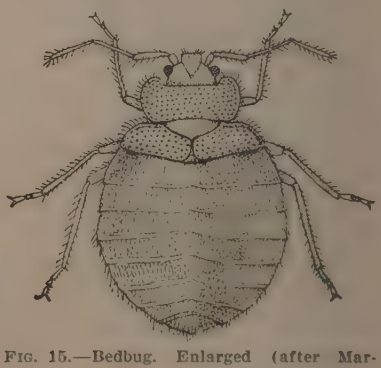

FIG. 15.—Bedbug. Enlarged (after Marlatt).

with such patients or by proximity to them, but that it is conveyed by the bite of a certain species of mosquito known as *Stegomyia*

calopus (fig. 16), which abounds in regions where yellow fever is possible. The bite of this mosquito, however, does not convey yellow fever to a healthy person until twelve days have elapsed from the time when the same mosquito has bitten a person suffering with the disease. It follows from this fact that by keeping yellow-fever patients screened from the possibilities of mosquito bites we can prevent the yellow-fever mosquito from becoming infected. It follows further that by preventing healthy people from being bitten by mosquitoes we can keep them free from the disease even where infected mosquitoes exist. And it follows still further that by the adoption of remedial measures looking toward the destruction in all stages of the yellow-fever mosquito we may reduce to a minimum the possibilities of the transfer of the disease. After demonstrating the fact, the medical officers of the Army in Cuba put these measures into effect, and the results were most gratifying. The health of Havana immediately improved, and the general health of Cuba and the industrial conditions dependent upon better sanitation have continually gained since.

FIG. 16.—*Stegomyia calopus.* Enlarged (author's illustration).

The New Orleans outbreak of yellow fever in the summer of 1905 was quickly stopped by antimosquito measures, and it is conceded that more than 4,000 lives were saved in that city during that season by the intelligent application of measures based upon the discovery of the United States Army surgeons in Cuba in 1900 and 1901.

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